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Practice

Offshore Software Maintenance Methodology

M. PAVAN KUMAR, V. SITA RAMA DAS AND N. NETAJI
Satyam Computer Services Limited, Mayfair Center, S. P. Road, Secunderabad 500 003, India

SUMMARY

Outsourcing of software maintenance is relatively new. It has been growing at a rapid rate in the last few years as companies have realigned their work-force *vis-à-vis* the core business. One of the main reasons for outsourcing the maintenance activity is economics. Another is the shortage of skilled personnel. Offshore maintenance (remote maintenance) can be the most cost effective approach in outsourcing. This paper presents an offshore maintenance methodology which has evolved and been refined over a three year period. The methodology encompasses both the technical and management processes. Three brief case studies highlight specific issues and their resolutions.

KEY WORDS: software maintenance; maintenance methodology; software economics; offshore maintenance; remote maintenance

1. INTRODUCTION

The maintenance phase is the predominant life cycle phase and the most expensive activity during the lifetime of a software product. This phase takes up approximately 67% of the total cost of the product (Schach, 1994; Sakthivel, 1994). The real value is quite considerable of having the software product perform as needed (Chapin, 1993)—a value highly visible to top management.

Two standard definitions set the context of maintenance activity:

- *The IEEE Standard 1219–1993 Standard for Software Maintenance* (IEEE, 1993, p. 4), defines maintenance as 'Modification of a software product after delivery to correct faults, to improve performance or other attributes, or to adapt the product to a modified environment.'
- *National Bureau of Standards Special Publication 500–106 Guidance on Software Maintenance* (Martin and Osborne, 1983, p. 6), defines software maintenance as '. . . the performance of those activities required to keep a software system operational and responsive after it is accepted and placed into production.'

Compared with development, the outsourcing of software maintenance is relatively new. Outsourcing of development work has been an accepted practice for the past twenty years

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or more in the USA and elsewhere (compare with Pei and Victoria, 1994). Maintenance has been traditionally the responsibility of the company where the application is active (for custom applications), or of the software vendor company, for three reasons (Chapin, 1987): the accessibility of the maintenance team, the local availability of the knowledge of the application, and the local availability of the knowledge of the business (product or domain). Taken together, these reasons made it almost mandatory that these companies maintain their own software.

However, for the past few years, many of the industries in the developed countries of the western world have been realigning their work forces in order to focus more on their core businesses because of increased competition. This has led those companies to look at economical means of maintaining the software. The key emphasis here is on the economics of maintenance. Outsourcing the maintenance activity to software houses in the western world has been found to be quite expensive as the cost figures are relatively the same as doing software maintenance in-house. This has caused companies in the developed countries to look to the developing countries for maintenance ('offshore' or 'remote' maintenance).

The objective of this paper is to show how offshore maintenance is executed successfully. In the next section, we present the methodology that we, an offshore maintenance provider, have evolved over a period of three years after considerable experience in maintaining medium to large software applications for client companies. The technical and the managerial concerns are highlighted to provide better understanding of the offshore maintenance process. Before we conclude, we present three brief case studies, each in different phases of execution using the methodology.

2. OFFSHORE MAINTENANCE METHODOLOGY

2.1. Key features

Three key features characterize the offshore maintenance methodology (Kumar, 1994):

- the technical aspects of maintenance,
- the communication infrastructure, and
- the management structure.

The technical aspects deal with the application and business knowledge, the way in which these can be acquired from the client company by the provider company, the tools and techniques used to help improve that understanding, etc. The communication infrastructure issues relate to the ways and means in which the network (typically via satellite) connections can be established, the protocols for communications between the client company and the maintenance provider, etc. The management structure reflects the hierarchy of the maintenance team, the commitment which both managements (client's as well as the maintenance provider's) need to make for the operation to be viable, etc.

2.2. Technical levels

To manage successfully a maintenance project, the provider first needs to understand the application. This understanding serves as a strong foundation in supporting the

operational use of the system in the user community. The programmers, designers, and analysts, with their knowledge of the syntactic structure of the programming language, general and specific knowledge of the business domain, construct a multilayered logical structure to represent the program and the application. The highest level of this structure is the meaning of the program.

From experience, we find the following empirical rule works well in accepting maintenance projects: *we need not know everything about the application(s) before we start maintaining them.* This rule has two important consequences.

The *first consequence* is that the knowledge can be acquired in stages. In reality, no programmer attempts to understand an entire program on a line-by-line basis; neither does the programmer attempt to understand the full functionality of the program at one go. This is a big task, and takes significant time. To attain a good grip on the application, we need to climb the ladder (of application knowledge) carefully and methodically. We need to build a multilayered information network in stages about the application. The experience gained in building these stages during a maintenance project provides the necessary knowledge (in the team) to be able to handle the assignments successfully.

The *second consequence* is that the complexity of the maintenance work undertaken is proportional to the level of knowledge acquired. The maintenance project methodology can be described as a sequence of three phases representing the amount of expertise gained by the offshore maintenance team in maintaining the software. This expertise guides us in identifying the classes of problems handled during each of the phases.

We classify the maintenance work undertaken into three major levels depending on the turnaround time required rather than the type of maintenance activity. These categories or levels indicate the time frames. The turnaround time reflects, indirectly, the capability of the offshore maintenance team to respond to the change requests taking into consideration the time-zone differences and the project specific skills. The three levels are these:

- Level I—system crashes and help desk. These need a turnaround of less than one business day.
- Level II—minor enhancements, minor modifications and minor corrections. These need a turnaround of less than a business week.
- Level III—major enhancements, major modifications and major corrections. These need a turnaround that depends on the scope of the work.

This partitioning of the maintenance problems helps us gain experience and expertise in maintaining the client's application(s). These levels dictate, to some extent, the kinds of assignments tackled at the beginning of the providing maintenance, and the gradual increase in the scope of the work leading up to taking over completely the full maintenance operation. It should be understood here that the maintenance contracts with clients are specified for a specific duration, and all activities of maintenance (viz., corrective, preventive, adaptive, enhancive) are considered as activities during the contract period.

We have partitioned the application knowledge into four categories so that the maintenance team consciously acquires knowledge in these categories. The kinds of knowledge the maintenance team needs are as follows:

- *Application execution environment.* This category covers the operating system, implementation language(s), the communication software, etc.

- *Operational knowledge.* This category covers the global information flow, the execution sequence (partial order) of the programs, the external interfaces between the (sub-) applications to databases, files and the job control scripts which control the entire operation.
- *Structural and design knowledge.* This category covers the application's implementation in two levels: (1) the architectural view and the global design; and (2) the lower level view of a single (small collection of) program(s). These two levels provide information about the control flow and data flow within the program as well as across the programs; how an individual program works (programming-in-the-small). The information about the program, database tables and files descriptions, data structures, the programming logic, the build (compile/link) dependency and sequence, etc. are important.
- *Business logic.* This category covers the business rules, the processing of the various transaction types, the exception processing, the kind of information needed by the organization under various circumstances, etc.

Partitioning knowledge into these levels guides the offshore maintenance team in seeking information on a need-to-know basis. This simplifies the logistics of technology/knowledge transfer between the client and the maintenance provider team.

Similarly, the change management procedures have been standardized and the roles and responsibilities of the maintenance team and client are clearly identified. In this way, the transfer of accountability from the client to the maintenance team can be controlled so as to be very effective.

2.3. Change management phase I

This phase is the starting point of technology transfer. The first step in transferring the application knowledge is to assemble the team. The maintenance team is carefully selected based on the above description of the kinds of knowledge required. The team composition reflects expertise in the execution platform, databases, operating system, programming language(s), business area to the extent possible, and application design and implementation. These skills are generic and do not necessarily pertain to the specific application being maintained. This helps the team in ramping up very fast with respect to the problem at hand.

This first phase of learning focuses on getting a minimal understanding of the application domain and a maximal understanding of the implementation. The maintenance team acquires this learning through formal training by the clients. We have had experience with two modes of this training: (A) the domain/application experts from the client team visit the offshore site and conduct the training; and (B) some senior members of the maintenance team visit the client site to get trained, and, subsequently disseminate this understanding to the entire team. Of these two, the client's experts visiting the offshore maintenance team is preferred because the client personnel get to meet most of the team members and there is a good opportunity for developing some personal rapport between the two teams.

Since this is a familiarization phase for the maintenance team, the client undertakes to provide the interface between the end users of the system and the team. During this stage, the client performs the majority of the decision making tasks. The technical issues

like preliminary analysis and effort estimating, are finalized at the client site by the client in consultation with the maintenance provider.

These activities are followed by the design of the maintenance task and the identification of the source code and documentation that will have to be modified are communicated to the offshore maintenance team. The offshore team codes these changes and tests the program(s) with respect to the implemented changes. The unit tested programs are communicated to the on-site team (client as well as the offshore co-ordinator) who integrate the program(s) into the production release after versioning the old system. The help desk functionality remains with the client. The reason why major responsibility is left to the client is to permit the client to control the pace at which the work responsibility is shifted to the offshore team, i.e., the pace is determined by the comfort level of the client. Since this is the beginning, the network infrastructure, management protocols, competency of the offshore team are assessed and expectation levels are established on both sides. This paves way for the subsequent smooth transitions from phase to phase. The stress in this phase is more on establishing and stabilizing protocols compared with technical issues. The duration of this phase depends on how fast the offshore team can come up to the client's expectations. Figure 1 shows the sequence of phase I activities.

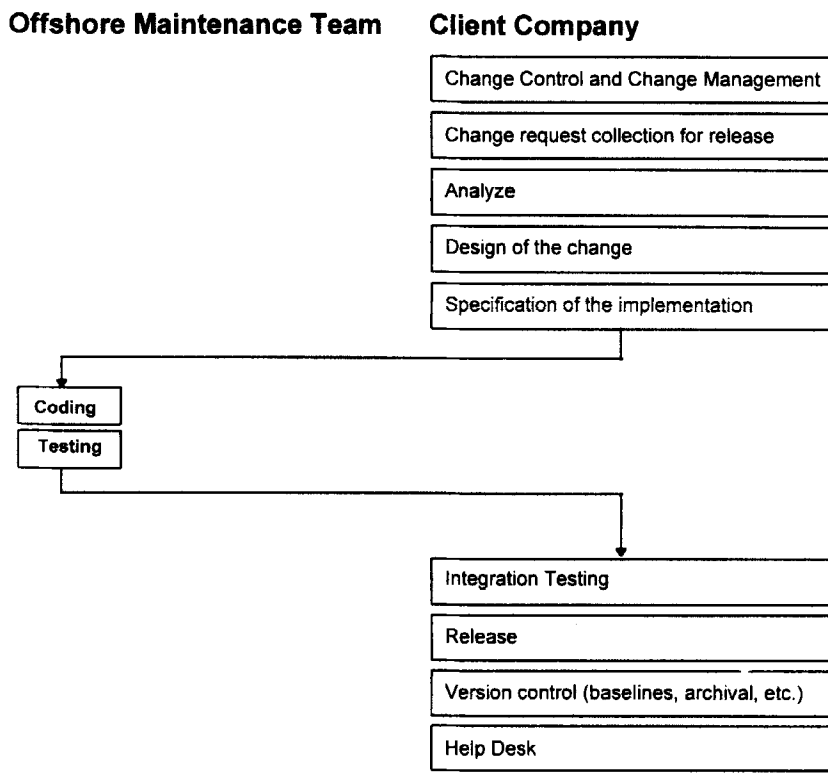

Figure 1. Phase I sequence of activities

2.4. Change control phase II

The transition to this phase happens after the infrastructure is stabilized. During this phase and the next two phases, the focus is on the technical issues. During the previous phase, the offshore team would have assimilated some level of business knowledge as bug fixes and minor enhancements are made. At this stage, a good (semiformal) understanding of the business logic is essential as the scope and complexity of the work increases. This is, again, achieved through the help of client personnel in the form of training. If the first phase of training happens at the client site, this phase happens at the offshore site. This helps in the client personnel to meet the team and exchange views about the progress. This phase of training focuses on the detailed design of the system, the design choices made, the global information flow, etc. This is the higher level of the structural knowledge. In addition, the team is also made aware of the way in which the business logic is encoded, the implications, the limitations, etc.

It is our experience that the client team hand-holds the offshore team through the first few assignments. They assess our understanding of the analysis, the impact evaluation and the change design. The implementation and testing would be done as in the previous phase. Depending on the assessment, additional training may be imparted. The control of release and versioning are still with the client. Some members of the offshore team visit the client site to get an understanding of the version control procedures, release procedures and the nature of the help desk. Typically two to three persons comprise the visiting team. This team would learn these functions under the guidance of the client team members. The intent is to transfer these functions in the later phases to the offshore site.

During this phase, we start documenting program level and system level information. Since this process is continuous, we perform this activity until the documentation is up-to-date and current for the system. To help this, whenever changes are made to the application (programs), we document those changes. We collate and insert these document pieces into the system documentation. This is essential and we have found that this helps a lot. This activity is done when the offshore team is not involved in the change release. Also, since all the team members may not be involved in each and every change, the free members continue the documentation. Figure 2 summarizes the phase II sequence of activities.

2.5. Change control phase III

By this phase, we have accumulated enough knowledge about the system that we can perform all the tasks related to the change requests except for the control of releases and assignment prioritization (collation). These still remain with the client. At this juncture, some of the on-site members of the offshore team would get trained in the two activities which are under the control of the client. The reason why these activities are left until this phase is that these activities are front end activities and involve interacting with the end users. The work so far handled by the maintenance team is of a technical nature and involves only the implementation terminology. The end user terminology applicable to the problems are still to be acquired. With the technical knowledge, the problem discussion and resolution and performing the housekeeping details of the change control becomes much easier.

The critical issue in these two tasks is when and what level of change requests will

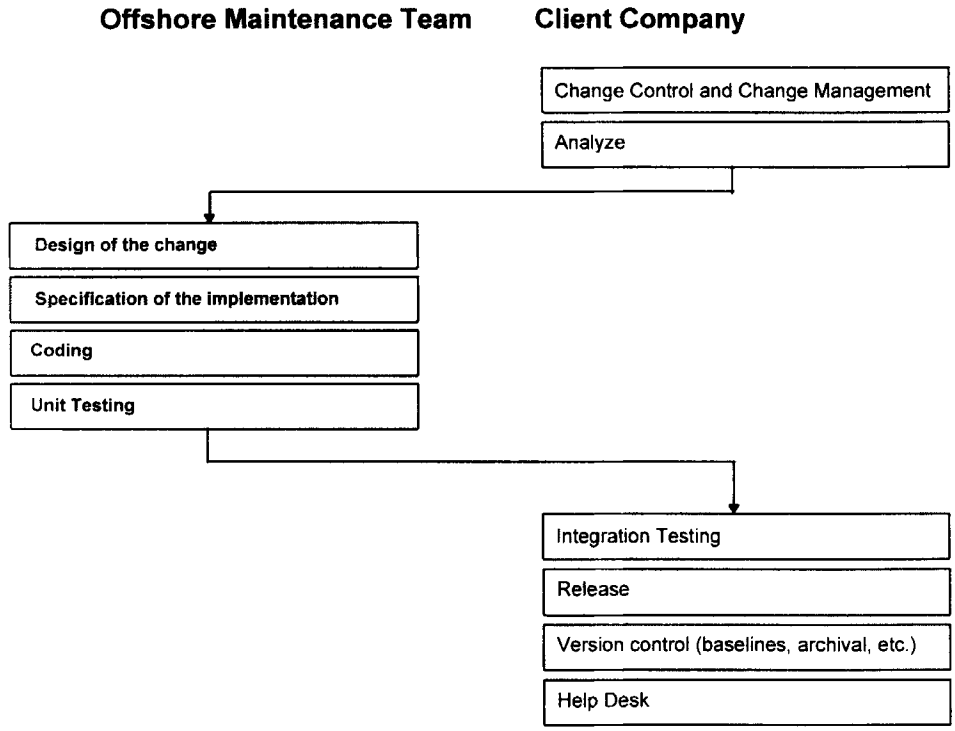

Figure 2. Sequence of phase II activities

result in the decision to release a new version. Our experience has been that this is very subjective. The general guidelines have been:

- For system crashes—to evaluate and prioritize (collate) all such incidents and associated requests, and schedule a version release, even for only one incident.
- For preventive maintenance (usually for bugs found during program understanding and documentation)—to combine them with other releases is the preferred alternative. The second alternative is to fix a number as a cut-off figure, and schedule as a separate release.
- For enhancive maintenance—for simple enhancements like changing report formats, adding new columns in reports, changing control breaks, adding new fields in screens, etc., to combine them with the current release. For complex enhancements like adding a new transaction type, changing business rules for processing certain transactions, modifying a database structure (single table, multiple tables or relationships), to treat as separate projects with their own schedules. These are then synchronized with the next scheduled release after the completion dates of these enhancements. The major reason for this timing is to preserve the integrity of the version control of the system—the enhancements need to be done with the same version.
- For adaptive maintenance—to evaluate and schedule after client consultation. For example, when a client changes the operating system, we have a lot of client

applications to change. We have found that mainframe users infrequently change operating system versions and database package versions, as compared with PC users. In the case of third party packages that are used in applications, the user tendency we have found, is not to change at all if the functionality by the current version is good enough. We have had requests (and done them) to rewrite some functionality in COBOL that used to be provided by third party packages no longer supported by the package vendors.

As regards help desk activities, usually the client allows us to take some of the problems independently. The usual scenario is this: a client team member gets the help call; that member evaluates the complexity of the request; if the request is simple or moderate, the call is passed on to the on-site-client maintenance provider member; and the request and the (re)solution are documented and discussed. Once the client team is comfortable with the results of this process, the work is slowly moved offshore.

Figure 3 summarizes the sequence of activities of phase III.

2.6. Change control phase IV

In this phase, we are completely equipped to handle the entire maintenance operation, from help desk to versioning and end-user support. At this stage, the offshore team is

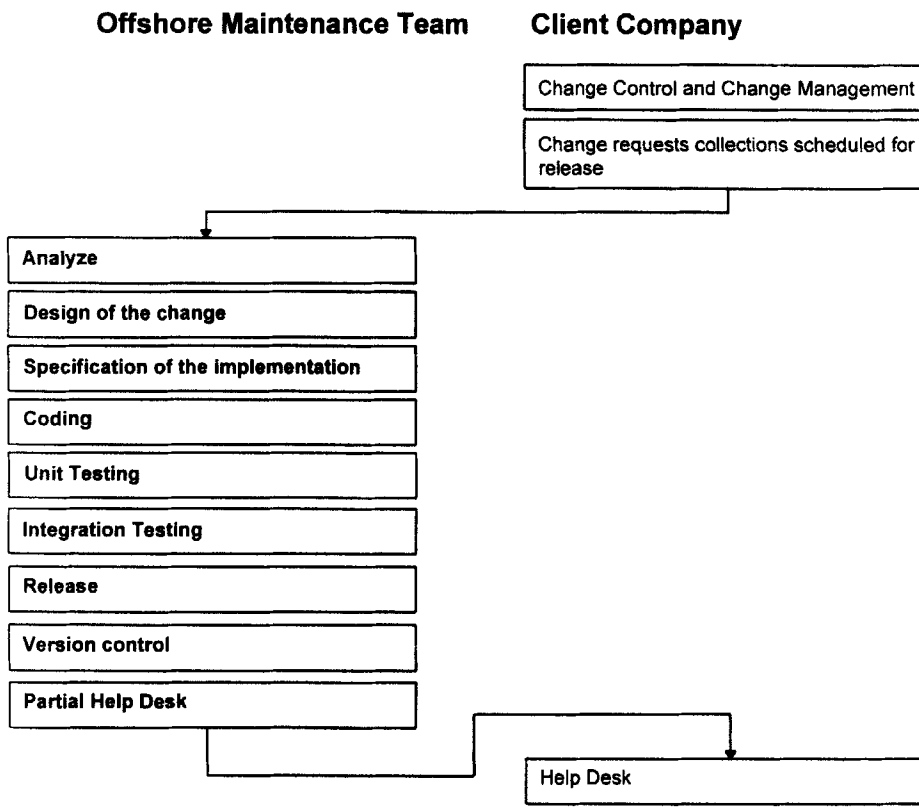

Figure 3. Sequence of phase III activities

capable of handling the change control and management as well. In this phase, except for an on-site co-ordinator and one or two members, the entire maintenance team is shifted offshore. After a transition period (generally about a month), only the on-site co-ordinator remains at the client site. The entire transition through the four phases can be diagramed as shown in Figure 4.

2.7. Metrics

Metrics provide a means of assessing the effectiveness of the maintenance activity. To this end, in our experience, the offshore maintenance team needs to collect the following metrics:

- *Size of the application and work force.* This metric provides a way of evaluating the effectiveness of the team with respect to the application size. The ratio of task size to team size is an indicator of how much of the system one person can maintain.
- *Change request traffic.* This metric is collected for each of the change request types: corrective, perfective, enhancive and adaptive. The first two indicate the stability of the application implementation. The number of enhancement requests indicate, to a certain extent, the stability of the application analysis and design. Too many enhancements in the initial stages of application use mean that the analysis and design has been less than thorough and that end-user concurrence has been partial.
- *Percentage change of code.* For each category of change request, how many lines are being changed, added or deleted. An additional, related, metric is the number of programs in the application that are changed. These figures would indicate the spread (impact) of the change request and help in prioritizing such changes. Lots of changes to the programs as well as many programs being altered, also indicates that more testing time will be needed.
- *Modification resources.* This figure provides the time/effort/cost for each category of change request. This is a useful metric. The less the time/effort (and hence the

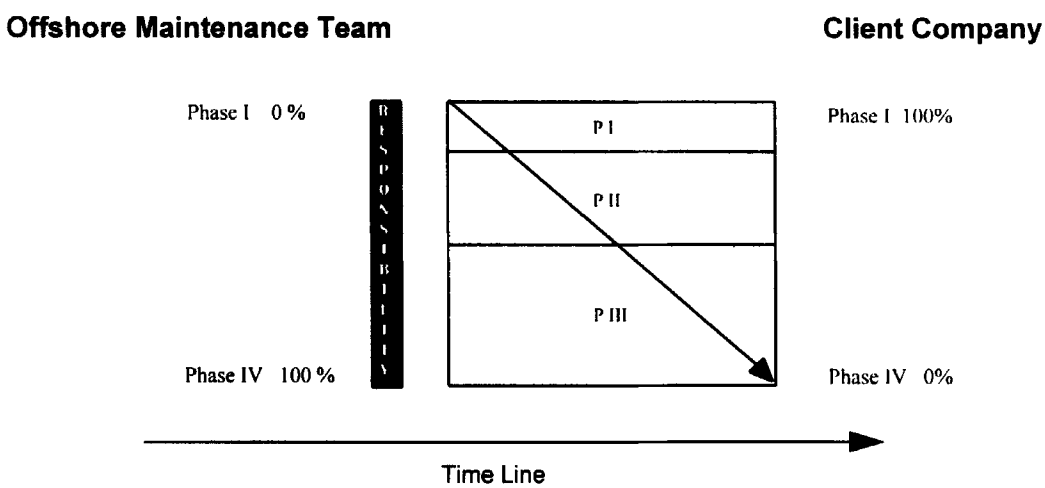

Figure 4. Accountability shifts as the phases progress

cost) means that the maintenance team is gaining expertise in the application domain. This can be used as a rough measure to guide movement through the phases (from learning phase I to complete maintenance control phase IV).

The duration of these phases depends on the complexity of the system, the implementation platform, and the expertise gained. An unstated but important factor is the co-operation of the client personnel in training and communicating with the offshore team.

2.8. Communication infrastructure

Perhaps the biggest hurdle for companies pursuing the offshore maintenance option is the communication infrastructure. Many companies are nervous about this matter. The serious questions which need to be answered are:

How do we communicate with the team?

How do we send and receive the application source code and documentation?

These questions are all the more critical with respect to developing countries as the communication infrastructure is not comparable with the developed countries. Communication is a concern even if the companies were to outsource maintenance within their own country. The communication done must address two major topics: the project status reporting and the actual change management of the application.

On the first topic, status reporting, our project management standards and guidelines make it necessary to establish the transparency of management. After the contract has been signed and the initial training program completed by the client, the project team creates and documents a software maintenance plan consisting of the four phases noted previously. The progress of the project can then be assessed with respect to this software maintenance plan.

Every week, we send a written status report to the client reporting progress in relation to the plan. In addition to this, weekly conference calls between the teams also help in resolving outstanding issues and informally transfering knowledge. We also do exchange site visits on a regular basis to explore ways and means of improving client benefit.

On the second topic, actual change management, facilities affect the process. The two major alternatives are: (1) have an equivalent environment (hardware and software) at the offshore centre; or (2) use a telecommunication (satellite link) facility to connect to the client computer facilities. The first option, by our analysis, has some serious drawbacks. One of them is that, as a software house, we have very many clients; each of them has a different environment. It would be very difficult to provide equivalent environments at our centre with reasonable cost. The second is that, even if we have our own mainframe to manage the application locally, we still need a communication link to transfer the source code and documentation ('sources') to and from the client site. Transfer of sources and other data by any other means (for example, air shipment of disks or tapes) is not a viable option as the time delay would be unacceptable.

We have chosen the second option of using a satellite link to connect directly to the client's centre. We thus avoid both compatibility difficulties and the cost of investing in a mainframe computer with all the facilities which our clients have. Owing to the time

difference between the two countries, we have had the additional benefit of using the client's machines during their slack time (night time) when the processing load is sufficiently low.

2.9. Management factors

More than the technical competency factor, the managerial commitment and concurrence has been the main reason for the slow pace at which the offshore outsourcing has been growing. It is only the economic factors which are now compelling the companies in the developed countries to hasten the pace of offshore outsourcing.

Since two diverse teams have to work together to accomplish this task, the management structure reflects this. The structure which we have found to be most successful is shown in Figure 5.

The management structure shows a senior manager from the client company heading the offshore maintenance work as the client's project manager. This has two benefits: (1) the client maintenance team members are aware of the strong commitment of their management to this venture; (2) the client maintenance team members have some degree of control over the maintenance work. This factor, we have found in our experience, is very critical. The senior manager would help respond to and overcome any reservations the client personnel may have with respect to their job security. In one case where this was not the situation, the offshore team had difficulties in getting the required skills/knowledge from the client team and the project was delayed inordinately. A consequential benefit of this management structure is that it keeps the offshore maintenance company from getting involved in the internal management affairs of the client company. The client senior manager provides a single point liaison with respect to both the client's maintenance team and the offshore maintenance provider team.

The client maintenance team should have two components: an on-site component; and an offshore component. The on-site personnel have two responsibilities: to co-ordinate the activities of the offshore personnel and to acquire the requisite knowledge to be able to assist the client in achieving a fast turnaround for maintenance problems. Typically, these

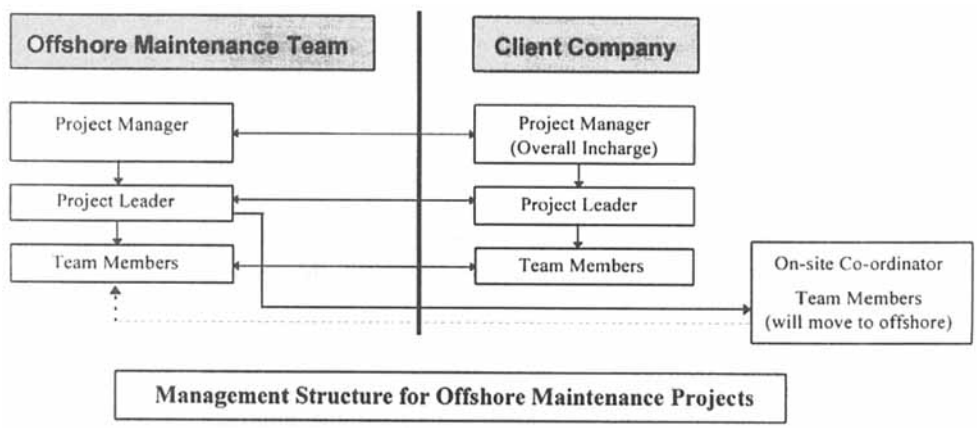

Figure 5. Management structure for offshore maintenance projects

on-site client personnel are analysts and/or designers who have had prior experience with both the hardware and software, and who have line-of-business (domain) knowledge.

The client's offshore maintenance personnel should be guided by the offshore project manager who is responsible for the offshore maintenance project. As noted earlier, this project manager provides weekly status reporting of the work in progress.

During the project, the client is responsible for imparting application and business knowledge. In addition, the client provides the necessary documentation and standards/guidelines followed in the client company and to be adhered to by the offshore maintenance provider. As the project progresses and the offshore team takes on more and more responsibilities, the client project manager should initiate, guide and moderate the interaction between the offshore maintenance personnel and the client end users of the systems being maintained.

The offshore maintenance team's responsibilities include executing the project as per the guidelines set by the client. One of the major responsibilities is to acquire the tendered application knowledge as rapidly as possible so that client intervention (assistance) can be reduced as far and as quickly as possible. The lack of skilled personnel is one of reasons for outsourcing and we need to make sure that the offshore team reduces the work load of the existing personnel of the client. To this end, we use a variety of techniques to speed the acquisition of the application knowledge, as noted earlier.

3. CASE STUDIES

3.1. Introduction

We briefly present three case studies to highlight the offshore maintenance experience. Each of them is in a different phase. All of these clients are IBM mainframe users and are based in the USA. With all, we connect with the client computer centres via satellite links. All three case studies cover five topics: project, training, project work, communication and current status. The same management structure is common to all three projects underway, and has four major components: a senior manager from the client company serves as the project leader at the client site of the offshore maintenance work; a small team from the client company works at the offshore site; a small team works at the client site but is staffed from the offshore maintenance team (to co-ordinate the maintenance activities); and the offshore team works at the offshore site, with its project leader.

3.2. Case study A

Project

The project is a medium size insurance system including one million lines of source code organized into more than 400 programs in a combination of on-line, batch and report runs. This project is in phase I.

Training

Two senior client representatives, after the signing of the contract, visited our centre with two goals: (1) to meet the maintenance team and evaluate the competency of the

members with respect to the requirements; and (2) to impart business and application knowledge to the offshore team. The client conducted a two week course for all the offshore team members. At the end of two weeks, the client representatives went back with a very positive feeling, confident that the methodology would be a success. This feeling was communicated to the rest of the client team members. This has tremendously helped in the project as the technical issues could then dominate, with the managerial issues having taken a back seat.

Project work

The initial change requests had a turnaround of one week and the on-site team provided all the help needed to fix the problems. In fact, the first two change request were done completely under their guidance. This has established confidence in the client team that practice of our methodology was also feasible.

Communication

Weekly conference calls have helped establish a good rapport between the two teams and all outstanding issues have been solved with mutual consent. These calls also helped in providing the application knowledge and/or business knowledge required to solve problems on hand. In addition to these calls, the status of the work under progress has been communicated to the client regularly via written reports.

Current status

The client has started training at its site for the visiting team to handle change requests which need to be completed within three to four days. This team is now ready to get back to our centre to carry out further work. With respect to this client, we are about to go to phase II operations.

3.3. Case study B

Project

This maintenance project for an insurance company is for a system of about 1·5 million lines of source code organized into more than 500 programs operating in a combination of on-line, batch and report runs. This project has completed phases I and II. We have recently entered the phase III mode of operation.

Training

Unlike the case study A project, senior members of the offshore maintenance team visited the client site to study the system and learn the procedures and protocols followed by the client with respect to the maintenance. They returned to our site and trained the rest of the team members. In this instance, the client has had the opportunity to meet at its site only the senior offshore personnel.

Project work

The client is now sending us the end-user specified change requests after prioritizing them. The release of versions to satisfy the change requests is being decided by us. We are also now in a position to talk to the end users directly for clarifications regarding the change requests.

Communication

Weekly conference calls, and the use of a mainframe-based e-mail package have helped keep the communication active and regular between the teams.

Current status

We are now undertaking a confidence building exercise with respect to the end users as we continue to progress in phase III.

3.4. Case study C

Project

This maintenance project has roughly the same characteristics as case study B, but is for a manufacturing company. This is one of the first maintenance projects undertaken and has reached phase IV. In fact, we had an advantage before starting the project with this client. We had completed some development projects for this client and hence had established credibility and competency already. Another distinguishing feature of this case study compared with the previous ones is that the training was done at both our site as well as at the client's site.

Training

Training was done at the client site for senior members of the offshore team.

Project work

Change requests arrive directly from the end users.

Communication

Weekly conference calls and written status reports are the primary vehicles, similar to those noted in the other case studies. They help provide and retain the transparency of project management.

Current status

Two senior personnel from our centre staff the help desk at the client site, and in conjunction with the client team, help handle critical bug fixes. These two personnel are expected to return to the offshore site soon. We are awaiting the beeper (pager) support from the telecommunication department. When this facility is available, we expect to be

in a position to handle all aspects of the client's software maintenance work with only a routine monitoring by the client team.

4. SUCCESS FACTORS

It is no easy task to perform fully on a software maintenance contract using a team other than the organization's own development or regular maintenance team, irrespective of being offshore or just down the street. This is especially true in the case of legacy systems coded in archaic styles and having little or no documentation. Despite this, we have been successfully maintaining application software offshore for clients. In our experience, the following are some of the most important reasons why this has been achieved:

- *Attitude.* The most important success factor is the attitude with which we approach software maintenance. We have sought and established a long-term relationship which helps the offshore team to work as partners (collaborators) in the maintenance phase rather than as temporary contractor/employee fill-ins. The offshore team works as an extension of the resources the client has at its own site. That is the reason we allocate teams on a long-term assignment basis.
- *Competence and adaptability.* We have a good resource pool of very competent staff. This is an important factor if we consider the legacy systems to be maintained. Legacy systems on IBM mainframes have been coded in different languages and dialects (e.g., COBOL and its dialects, PL/I, assembly and its dialects, etc.). Offshore maintenance teams have been trained in these languages and dialects and possess excellent skills to maintain these software products. From our experience, we have not seen many personnel equipped with the skills in languages which are not currently in vogue. Added to this is the ease with which this pool adapts to the client's work culture, standards, processes and procedures within a short span of time. This greatly reduces the communication gap (technical as well as managerial) as the mode and means of communicating are standardized more easily to fit with the client's.
- *Phased approach to maintenance.* We have evolved a mechanism which allows (helps) us to acquire the application expertise in a manner which is effective and also which does not demand major resources from the client side. We have found that demanding major amount of resources from the client side is not a viable proposition. The lack of these resources is a main reason why the client is shifting the work to offshore.
- *Cost benefits to the client.* Offshore maintenance is very cost effective. Since this is a consequence of good management on both sides taking advantage of geographic-based differences, the companies opting for offshore maintenance can reduce the costs of software maintenance by a large margin, typically 30 to 50%.
- *Realignment of client's personnel.* The outsourcing company can release their own personnel from the maintenance task, and are then free to allocate those resources elsewhere. Since most Information Systems Departments of companies have limited personnel, if these personnel are tied down with maintenance, future projects suffer. For example, using offshore maintenance provides an opportunity to utilize the freed work force on new projects. Most of our clients have shifted their freed personnel to developing new applications. An interesting offshoot of the maintenance work

and the realignment of the client's work force is that clients have been asking us to participate in new development work as well because of the track record built handling the maintenance work. Since we have acquired the business knowledge relevant to their situations, clients find it easy to communicate their requirements.

- *Global reach.* Many companies are now expanding globally. This implies that the applications they have need to run at different computer centres which are spread across the globe. The number of users have also increased many fold. Even if the company would like to maintain the software, the work force it has is going to be inadequate and would find it difficult to service the users in different time zones. This is one of the reasons why some companies have opted for offshore maintenance in different locations so that their 'reach' can be enhanced to meet the requirements of all their users. In this instance, the offshore maintenance teams can form a large global network of maintenance teams to assist the users. Two of our clients have been asking us to set up a 24 hour support centre to cater to the application users in the far east (which is only a three to five hour time difference) in addition to the USA users.
- *Controlling staff turnover.* The offshore maintenance team ensures that the information available about the application is disseminated to and available to all team members. Even if there is a change in team composition, the inducted and leaving team members go through a hand-over process which ensures that the loss of expertise is minimal (contained). This helps in providing good quality service despite the employee turnover (this is a universal problem and cannot be totally avoided).

5. PROBLEMS AND SOLUTIONS

Offshore maintenance has its share of problems. In this section, we list some of the major ones and the solutions we have devised to reduce the unwanted consequences or to solve the problems.

- The most critical factor for offshore maintenance to succeed is the commitment of the outsourcing company. Consensus is one factor. If there is no consensus in the management that it will work, then the project is a sure failure. Attitude is a second factor, that is, the attitude with which both the companies approach the offshore maintenance. If either view the outsourcing as a on/off project, then trouble persists. If both view the outsourcing as establishing a long-term relationship, then ample opportunity exists to stabilize the protocols.
- The two most common serious concerns (risk perceptions) of the client management are the stability of the project team and the competency of the offshore personnel. The stability of the team is ensured by allocating a dedicated pool of personnel for each of these projects. As this team spends more and more time in the same project, the experience gained is retained by the team and the benefits accrue to the outsourcing company.

  Competency gets addressed by the offshore maintenance methodology. Each of the phases provide adequate mechanisms to evaluate the competency of the team. The metrics collected provide the necessary numbers to be able to assess, as well as fine tune, the performance of the team. Furthermore, to reduce this risk perception, we invite the client company management as well as the client technical group to

visit the offshore site and to assess the realities. The training courses conducted by the client's company technical team are also an evaluation point. So far, from our experience, we have seen the client company personnel come away with a very positive attitude at the end of these sessions.

- The project management is another concern. The client company has its own standards. The concern here is whether the offshore teams would follow these or not. Another concern is whether or not the offshore management is good enough to ensure high quality software. We have very stringent project management standards ourselves, and, in cases where the client insists on their standards being followed, this has been implemented. We have also made the management transparent in the sense that the plans, processes and standards are available to the client to review and suggest changes that would increase their comfort level.
- Robustness of the communication hardware is also critical for the success of offshore maintenance projects. We have built enough redundancy in the links to ensure that there is minimal disruption in the communication and it being further improved with respect to the bandwidth. Currently, we have two 64KB links to the USA, and we are acquiring more capacity. In addition, we use e-mail and any proprietary mail packages of clients to communicate on the status and technical matters regarding the project. In addition, we also have conference calls regularly (usually weekly) to improve communication. This has a very positive psychological impact on improving the relationship between the two teams. This factor also affects the help desk support from offshore.
- With regard to the technical matters, some of the problems are as follows:

  Business and application knowledge. The methodology addresses this issue and makes it practical to implement. We first need to learn as much as possible of the implementation details in order that minor bug fixes and enhancements can be made. To achieve this, minimal business knowledge is adequate. What is important is sufficient structural knowledge of the source code to be able to design and apply the fixes. As we progress through the phases, the team acquires the business knowledge. This methodology provides for the knowledge acquisition on a need-to-know basis.

  Documentation. In most of the projects, the documentation is not adequate, and often, out-of-date with respect to the code's execution behaviour. One of the exercises undertaken by the maintenance team is to document the code to improve both understanding and understandability. This documentation is reviewed and validated. As the team increases their expertise, they would document the design decisions and business logic as well. Over a period of time, the documentation is brought up-to-date to match the application's current source code.

  Synchronization of change control. This is a problem that crops up during the initial stages of the project. One difficulty is when the client has more than one active co-ordinator for change requests. The offshore team could then sometimes be working at cross purposes on the same or different versions of the program for different changes. This causes problems in scheduling the versions and synchronizing the code changes. One of the ways we have found to reduce this is to have a single co-ordinator or a board whose members represent a stable defined membership.

  End-user change requests. This problem, again, is only in the initial stages (in phases II and III). When the offshore team gets the end-user requests directly,

understanding of the intent of the change is necessarily more complete. Before an implementation is initiated, the offshore team communicates their understanding and the impact of the change request to the on-site team. After concurrence is obtained, the offshore team then proceeds to implement the change. This problem is partly linguistics, and partly due to inadequate business knowledge.

Synchronization of corrective and preventive maintenance. During some of the bug fixes, we have detected other problems with the system. The problem then expands to synchronizing the bugs detected at the offshore site and in the current release. It may not be possible to merge all fixes into the current release because of the varying impact of these changes.

6. CONCLUSIONS

The offshore maintenance concept has come of age and the developing countries are increasingly becoming the focus points for western world attention. Our offshore maintenance methodology has worked well and we are striving to make it still better. The most important parameter in succeeding is the total commitment by the client management. As the communication infrastructure is improving in the developing countries, the maintenance service is also improving. This helps in ramping up very fast through all four phases and in being able to handle the three categories of problems within a short span of time.

The biggest advantage from the client's point of view is the economic benefit of offshore maintenance. The second advantage is the number and quality of skilled resources available that are allocatable to the project on a long term basis. This implies that the benefit of the experience gained by the team in the initial phases accrues to the clients because of reduced personnel turnover.

Since our methodology has been in practice for three years, we have been through teething problems and fine tuned our methodology to reduce the impact of technical problems. Currently, this methodology is quite stable and has helped us to execute the offshore maintenance projects successfully. It is also true that three years is not a long time to have a very mature and stable model/methodology. Our internal quality assurance procedures and the metrics collected from the projects help us both in evolving this model and in improving the process further in order to further improve the maintenance service.

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References

Chapin, N. (1987) 'The job of software maintenance', in *Proceedings of the Conference on Software Maintenance—1987*, IEEE Computer Society Press, Los Alamitos, CA, pp. 4–12.

Chapin, N. (1993) 'Software maintenance characteristics and effective management', *Journal of Software Maintenance*, **5**(2), 91–100.

IEEE Computer Society (1993) *IEEE Standard for Software Maintenance*, IEEE Computer Society Press, Los Alamitos, CA, 39 pp.

Kumar, P. M. (1994) *Software Maintenance*, Technical Report, Internal document of Satyam Computer Services Limited, Secunderabad, India, 16 pp.
Martin, R. J. and Osborne, W. M. (1983) *Guidance on Software Maintenance*, National Bureau of Standards Special Publication 500–106, Superintendent of Documents, Washington DC, 66 pp.
Pei, G. and Victoria, A. (1994) 'Reusability in software maintenance: a Japan–USA comparison', *Journal of Software Maintenance*, **6**(4), 165–183.
Sakthivel, S. (1994) 'A decision model to choose between software maintenance and software redevelopment', *Journal of Software Maintenance*, **6**(3), 121–143.
Schach, S. R. (1994) 'The economic impact of software reuse on maintenance', *Journal of Software Maintenance*, **6**(4), 185–196.

Author Biographies:

M. Pavan Kumar is a Principal Consultant with Satyam Computer Services Limited and is currently heading the 'Center for Expertise'. His primary responsibilities include improving software process methodologies, metrics, and tools.

Born in 1958, in Hyderabad, India, Pavan obtained his Bachelor's degree in 1979, in Electronics and Communication Engineering. He graduated with a Master's in Computer Engineering in 1981.

Pavan has fifteen years of experience in various organisations in various capacities. Prior to joining Stayam he worked for Tata R&D Centre in the Software Engineering and Language Processing Group. During leisure time, he likes to listen to classical music and enjoys reading biographies.

V. Sita Rama Das is Consultant at Satyam Computer Services Limited and is currently managing offshore maintenance projects. His primary responsibilities include project management and also a liaison between the clients abroad, and the offshore maintenance teams in India.

Das was born in 1958 in Andhra Pradesh, India, and obtained a Bachelor's degree in Electrical Engineering in 1979.

Das has over 15 years of experience in data processing and software consultancy. He has worked with various industries like Bokaro Steel Plant, and Computer Maintenance Corporation, besides international giants like EDS and Anderson Consulting. During his tenure at various organisations he has been involved in all the project life cycle activities and has provided consultancy for many clients.

N. Netaji is a Principal Consultant with Satyam Computer Services Limited and manages the offshore project execution. He has worked extensively on IBM mainframe systems for the last 15 years both in India and abroad.

Netaji was born in 1957 in Andhra Pradesh. After obtaining his Post-Graduate degree in Electrical Engineering from the Indian Institute of Technology, Kharagpur, in 1982, he moved to the computer software business in the areas of computer software development and maintenance.

His favourite hobbies, besides computers and related subjects, is listening to Indian Classical Music.